A NEW QUILLWORT.

RAYNAL DODGE.

(WITH PLATES IV AND V)

IN the early summer of 1895, Mr. Alvah A. Eaton of Seabrook, N. H., noticed at East Kingston, in the same state, a plant which proves to be a new species of Isoetes. This plant was found on Powwow river "flats," which comprise a nearly level, somewhat irregular tract of land, about a half mile wide and a mile and a half long, through the middle of which during summer the Powwow river flows, but for six or eight months of the year the area is for the most part submerged. The plants are scattered all over this locality, being however not at all gregarious; some having been found in the latter part of July growing up to high water mark, accompanied by *Agrostis vulgaris*, *Poa compressa*, *Trifolium repens*, and various asters; whilst others were thriving in the river, immersed in six inches or a foot of water, and accompanied by such aquatics as *Scirpus subterminalis*, the plants in the latter instance floating their enormously long leaves on the surface. The soil in this locality is a deep alluvium underlaid with sand, and upon its surface, besides the Gramineæ and Junci which usually occupy such situations, several species of Isoetes grow, for the most part gregariously, among which I recognize *I. riparia*, *I. Engelmanni*, *I. echinospora Boottii*, and *I. echinospora muricata*. These are accompanied by the peculiar species which I propose now to discuss.

This interesting form, which I name *I. Eatoni* in honor of its discoverer, is seldom found growing very near another of its species, but the plants are from a foot to ten feet apart, and are thus dispersed throughout the station. It is noticed at a higher level than any of the forms with which it is associated, and if it does not also occur at a lower level, it at least has that appearance,

for when in the deepest water it is surrounded by such a tangle of Gramineæ, Junci and Scirpi, that it is detected only by its long floating leaves, when shorter leaved forms would pass unobserved.

In common, I think, with all amphibious species of this genus native to New England and growing under the conditions mentioned, this species has two sets of leaves, differing somewhat in structure, but especially in dimensions, the longer constituting its spring dress when submerged, and the shorter its summer dress when living in the air and exposed to open sunlight. The vernal leaves are very long, sometimes attaining the length of 28^{in}, but as I have seen them only in early summer, when by the falling of the water their upper portion was floating and decaying, I am not sure what position they assume when wholly submerged, but I suppose they are erect spreading.

By further recession of the water, these vernal leaves become prostrate and soon decay to the base, which usually remains covering the sporangium, the spores maturing only when for some weeks exposed to the air and sunlight. The plant now produces within the old a new set of leaves which, excepting the central ones, are nearly decumbent, the matured spores and dead portions being gradually thrown off by the downward lateral growth of the corm. These æstival leaves are from 3 to 6^{in} long, with a more or less pronounced lateral curvature which serves to distinguish this plant from the larger forms of *I. Engelmanni*. The outermost of these æstival leaves are found late in the season to include at their bases matured sporangia; in fact, on the highest ground, the plants getting an earlier start perfect their spores during the whole summer and early autumn. These outermost and matured leaves then decay, but the inner and immature remain, are covered by water, survive, probably even in winter vegetate to some extent, and on the approach ot warmer weather undergo a rapid increase in dimensions, as evidenced by a plant kept in a jar of water during the past winter, which, beginning early in April, in a few weeks increased the length of its leaves threefold.

Full grown plants of this species are immediately recognized among others with which they may chance to be associated, when immersed by their long floating leaves, and when emersed by the very large diameter of their assembled macrosporangia, which in one instance in a fresh plant was $2\frac{3}{4}^{in}$, a diameter of 2^{in} being common; but it may be remarked in passing that desiccation produces a shrinkage of from 25 to 40 per cent.

Thus *I. Eatoni* is unsurpassed in dimensions by any known North American species, and only equaled, if at all, by Engelmann's *I. Engelmanni valida*, which as yet has not been noticed in the New England states. *I. Engelmanni*, with which our present species has perhaps been confounded, is abundant in eastern Massachusetts, growing in nearly every brook and slow running stream, and is quite common even in ditches, but I have not seen plants with leaves more than 16^{in} long, nor with bulbs more than an inch in diameter, specimens of this size being quite unusual. The number of leaves in full grown plants of *I. Eatoni* varies from 50 to nearly 200, the greatest number yet noticed having been 187.

The most striking characteristics of this species are: the paucity of microspores; the irregular occurrence of peripheral bast bundles in the leaves; the peculiar sculpture of the macrospores; the straightness of the commissural ridges; and the low angle they form with the equatorial plane. Previous to drying the well grown plants of this species, large and filled with moisture as they are, it is well to cut each plant into two parts, making a section at right angles to the natural division of the trunk. I have divided a great many in this way, but in the largest no sporangia containing microspores have as yet been detected. Several plants have been noticed which contained from ten to thirty microsporangia, and few or no macrosporangia, and about a dozen which held microsporangia irregularly scattered among the others. On the other hand several hundred plants which have been examined apparently contained only macrospores.

It has been remarked by Alexander Braun and other Euro-

pean students of the Isoetaceæ that the largest plants of a given species contain relatively the fewest microsporangia, but I think that no such extreme instance as this of our present species has been recorded, and it is quite in contrast with the habit of *I. Engelmanni*, its nearest congener, in which microspores can always be found, excepting when the plants are very small or poorly developed.

The larger plants of *I. Eatoni* produce annually thousands of macrospores, probably continuing to do so for many years, and yet the station where this species occurs is far from being fully occupied, so that this infrequent occurrence of the microspores would seemingly account for the dispersed manner in which the plants are found to grow. It is to be noted, on the other hand, that the sporangia are very large, often a half inch long, each microsporangium containing doubtless several million spores.

The leaves of *I. Engelmanni* are found always in my experience to contain peripheral bast bundles. In this species they are present in some leaves, but not in others of the same plant, and from some plants they are apparently altogether absent. They are often weak, but occasionally well developed, and occupy the same position as in *I. Engelmanni*.

Those who are familiar with the classification of the species of Isoetes, as elaborated by A. Braun and adopted by Engelmann, Baker, and Motelay, will notice that the position of *I. Eatoni* is quite abnormal when considered in reference to its mode of growth and to the presence of bast bundles.

The sculpture of the spores in this species is labyrinthiform-convolute, having about the same appearance as brain coral, the walls being wide, and not, as in *I. Engelmanni*, composed of thin fragile laminæ.

A marked feature of the macrospores is that the commissural ridges are perfectly straight. The angle which these ridges make with the equatorial plane of the spore is sometimes so low that the upper end of the spore is very flat, but the average angle is about twenty-five degrees. This gives the spores a tetrahedro-globose form, sometimes noticed in the immature

spores of other species, but a constant character in the matured spores of *I. Eatoni*. The macrospores are quite small, the commissural ridges usually cristate, and the epidermis of the sporangia, in *I. Engelmanni* unspotted, is in this species often covered with light brown sclerenchyma cells.

Although I have visited three times the locality in East Kingston where this species occurs, I am yet indebted for many of the foregoing facts to the discerning eye and untiring efforts of Mr. Eaton himself, who has taken much interest in the inconspicuous but interesting plants of this family.

Isoetes Eatoni, n. sp.—Trunk stout, 6–48^{mm} in diameter, bilobed, diameter of bulb sometimes 66^{mm}: vernal and immersed leaves 50 to nearly 200, 38–71^{cm} long, with an elevated ridge on the ventral side, strongly winged near the base, the wing decurrent into a broad (3^{mm}) hyaline margin, which is furnished with slender irregular hooked teeth, median section nearly triangular in outline; æstival leaves much shorter, 7.5–15^{cm} long, the outer nearly decumbent, median section approaching quadrangular; stomata abundant: peripheral bast bundles of irregular occurrence, often weak or wanting: sporangia maturing only when emersed, large, oblong, strongly arcuate, in well grown plants 10^{mm} long and 4^{mm} wide, nearly covered with very light brown sclerenchyma cells: velum about one-fourth indusiate: macrospores small, tetrahedro-globose, equatorial diameter 300–450μ, sculpture labyrinthiform-convolute, commissural ridges cristate: microspores 25–30μ in length, smooth or slightly papillose: plant polygamous.

Discovered by Mr. Alvah A. Eaton on the "flats," Powwow Station, East Kingston, N. H. One plant of this species has been found on the tidal tract of the Merrimac river at Newburyport, Mass., and a large number at Pautuckaway river, Epping, N. H., one of the latter being trilobed.

An interesting problem relating to the quillworts is as to the chemical nature of the clear white covering of the macrospores. It has the appearance of calcium carbonate and one almost expects to see it dissolve with effervescence in dilute acids, but a trial shows that no such action takes place. Reference to all

accessible authorities has led to the unexpected result that apparently no investigation of this subject has been made. Dr. Engelmann speaks of this integument as "a crust, chalky white;" Sachs is silent, as is the Micrographical Dictionary; Hofmeister says "the matter composing the exosporium behaves towards reagents like the exine of pollen grains. Sulfuric acid imparts a reddish color to the inner layers which are softened by boiling in alkaline lyes. The gelatinous layer is *rapidly destroyed by mineral acids* and caustic alkalies. Röper has observed that the exosporium does not contain calcium carbonate, although Schleiden suspected its presence from the appearance of the dry spores."

Experiments conducted with a view of becoming better acquainted with the chemical nature of the exosporium have led to the following results. The macrospores when strongly heated become brown and then black, and if the heat be increased to bright red, they still retain their form and sculpture and are white when cool. The exosporium is easily soluble in a solution of sodium hydroxide; it gelatinizes somewhat in boiling sulfuric acid, but after washing and cooling the macrospores *have the same outward appearance as before treatment.* By the action of potassium chlorate and nitric acid the endosporium is entirely destroyed, and the exosporium of many of the macrospores is fractured, but undergoes no other appreciable change. The exosporium dissolves rapidly in fluorhydric acid, and if to this solution sodium chloride be added, we obtain the characteristic hexagonal crystals of sodium silico-fluoride; the microchemical test with sulfuric acid for calcium oxide shows its presence in minute quantities. No traces of potassium were detected with the spectroscope.

One hundred parts of macrospores which had been for several months air dried were found to suffer a

Loss at 100° C. of - - - - -	4.11
Loss by burning - - - - - -	20.96
Residue - - - - - - -	74.93
	100.00

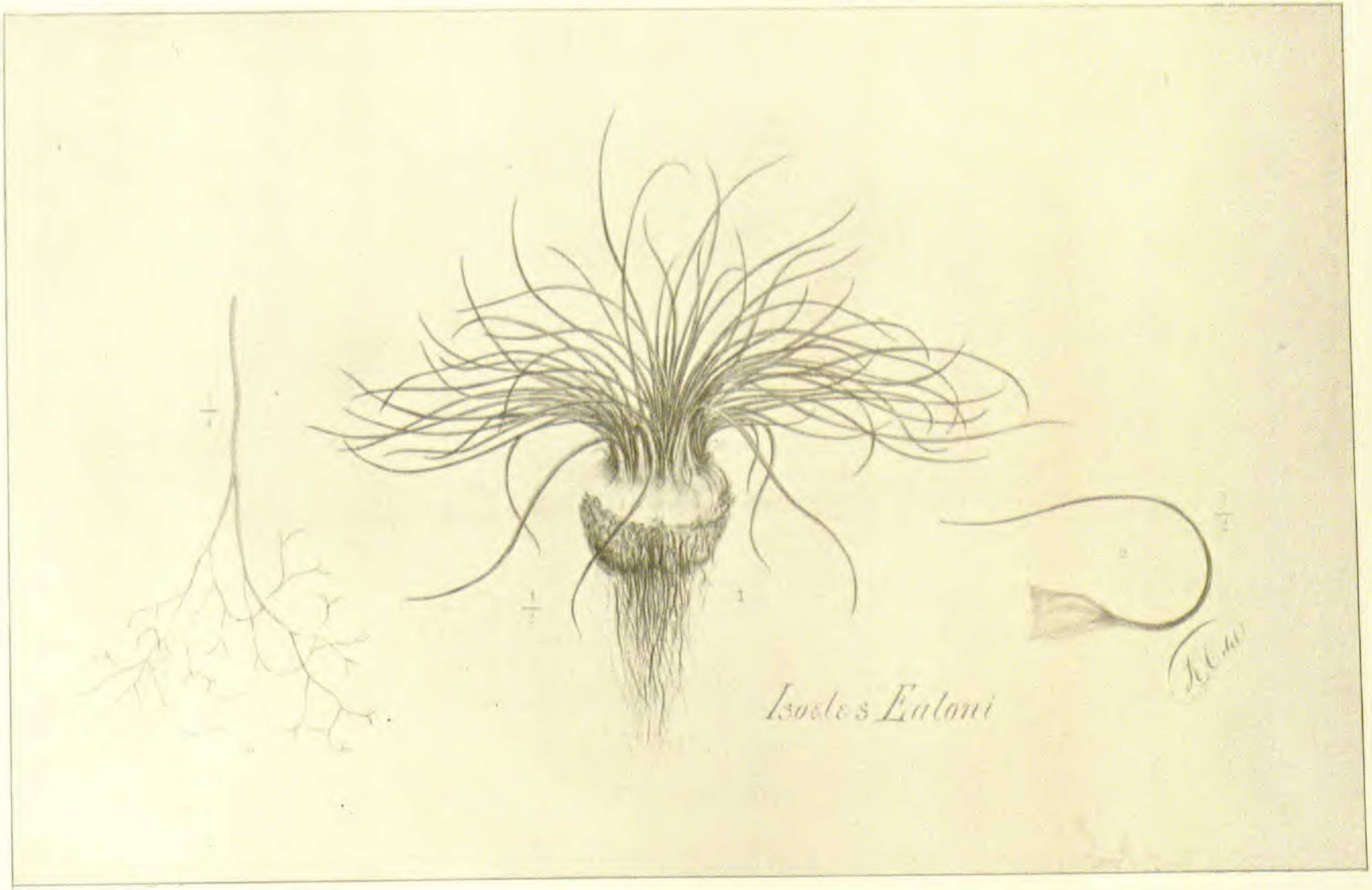
No attempt was made to determine the amount of incombustible matter in the exosporium, as it was found rather difficult to collect it in sufficient quantity. It is evident from the foregoing reactions that the residue is very largely silica.

We also find by calculation that the incombustible residue forms 78.14 per cent. of the spores dried at 100° C. The macrospores when divested of their exosporium are found to be very combustible, leaving when pressed on white paper a transparent stain, and can hardly be supposed to contain less organic matter than the exosporium itself. If we adopt this supposition, we find that the integument contains about 90 per cent. of silica, which is a very large amount when we consider that the ashes of oat straw contain less than 5 per cent.

It is quite possible, moreover, that the blackening of the macrospores when they are first subjected to heat is caused by discoloration from the gases produced by the ignition of the endospore; indeed it is questionable whether the exosporium contains organic matter. This naturally could only be decided by the collection and examination of a considerable amount of the integument, an undertaking that requires a larger opportunity and better facilities than the author has been able to bring to bear upon it.

It is perhaps worthy of remark that *I Eatoni*, from its polygamous character and the number and size of its macrosporangia, furnishes, with but little labor, a large amount of macrospores free from microspores, and it was upon the macrospores of this plant that the previously mentioned experiments were made.

An examination of *pl. V, fig. 4* will show that a macrospore of *I. Eatoni* when divested of its integument is marked by faint ridges. In the case of *I. Engelmanni* these ridges are reticulated, and the endospores of *I. echinospora* are dotted with small low tubercles. It is at these little elevations that the spore secretes the greatest amount of silica, and it is this extra secretion that gives character to the so called spore sculpture. But it is evident that these silicious markings of the exospore are not produced by sculpture, or by any analogous process, and it is suggested



ISOETES EATONI Dodge.